

REMARKS

Claims 1-9, 11-13, 22, 26-35 and 37-64 are now pending. Claims 19-21 and 26 have been withdrawn from consideration. Claims 10, 14-18, 23-25, and 36 had been cancelled without prejudice. No claims stand allowed.

Claims 58 and 62 have been cancelled without prejudice by this amendment. Claims 57, 59, 61, and 63 have been amended to further particularly point out and distinctly claim subject matter regarded as the invention. Claims 1, 12, 22, and 38 have also been amended. New claims 65-70 also particularly point out and distinctly claim subject matter regarded as the invention. No "new matter" has been added by the amendment.

Rejections Under 35 U.S.C. § 103

Claims 1-2, 5-8, 22, 27, 30-34, 44, 49-52, 57-64 stand rejected under 35 U.S.C. §103(a) as being allegedly unpatentable over Chang et al. (U.S. Pat. No. 5,442,719) in view of Stoll (U.S. Pat. No. 5,902,519). Claims 3, 9, 12-13, 28, 35, 38-43, 45-48, and 53-56 stand rejected under 35 U.S.C. §103(a) as being allegedly unpatentable over Chang et al. in view of Stoll, and further in view of Chen et al. (U.S. Pat. No. 4,196,963). Claims 4, 11, 29, and 37 stand rejected under 35 U.S.C. §103(a) as being allegedly unpatentable over Chang et al. in view of Stoll, and further in view of Chen et al. and Byer et al (U.S. Pat. No. 5,714,198). These rejections are respectfully traversed.

According to M.P.E.P. § 2143,

To establish a *prima facie* case of obviousness, three basic criteria must be met. First there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in the applicant's disclosure.

Furthermore, the mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16USPQ2d 1430 (Fed. Cir. 1990).

Claims 1 and 22

Claim 1, as amended, defines an annealing method including heating the lithium niobate structure in a sealed oxygen gas atmosphere substantially lacking in H₂O, and pressurizing the sealed oxygen gas atmosphere to exceed ambient atmospheric pressure. Claim 22, as amended, also defines an annealing method including the same distinctive features.

The Examiner alleges that “Chang’s heating step reads on heating the lithium niobate/lithium tantalate structure in a sealed pure oxygen gas atmosphere substantially lacking of H₂O (to within a temperature range of 150-500°C).” However, Chang only teaches a heat treatment “in the presence of oxygen” (column 1, lines 56-57. column 2, line 29, column 4, line 6), and mentions only the flow rate of oxygen (column 3, lines 6-8

and 33-34) and temperature range of the heating process (column 1, lines 58-59, column 3, lines 9-10 and 29-31). There is no mention to prohibiting or avoiding H₂O in the heating process, or to undesirable effect of H₂O on the modulator (see pages 5-6 of the present specification). Thus, Chang neither teaches that the gas is lacking in H₂O, as claimed, nor suggests any motivation or desirability to avoid H₂O in the annealing gas atmosphere.

It should be noted that one of the significant features of the present invention is the combination of using pressurized oxygen and prohibiting water from the system. Water is prohibited from the system in order to prevent undesirable protons from remaining in the modulators after fabrication, since such free-flowing protons would cause DC-bias instability or drift (see page 6 of the specification), which is the applicant's finding. Furthermore, the pressurized oxygen keeps the crystal from degrading when water is not present in the annealing process. Chang teaches proton exchange waveguides in a preferred embodiment where protons are intentionally introduced. This actually teaches away from excluding protons from the process. In addition, Chang also uses isopropyl alcohol (hydrogen-containing solvent) as a cleaning agent, which would introduce protons to the system. Accordingly, Chang provides no motivation or suggestion prohibiting water or H₂O from the process.

In Stoll, the ion-doped lithium niobate crystal is protonated by subjecting to steam heated to 600°C (column 4, lines 11-12). Following the protonation, the crystal is placed in a pressure chamber and heated (column 4, lines 20-36). Thus, although Stoll applies

“dry, ultra-pure pressurized oxygen” to the chamber, H_2O would be present in the chamber since the steamed crystal is directly placed in the chamber after the protonation process. It should be noted that the key point of the present invention is to avoid such protonation process (see pages 5-6 of the present specification). Thus, Stoll’s protonation teaches away from prohibiting undesirable protons from the system, as discussed above. Therefore, Stoll does not suggest using a sealed oxygen gas atmosphere substantially lacking in H_2O , as claimed.

Thus, neither of Chang and Stall teaches or suggests prohibiting H_2O from the annealing process or system. Accordingly, Chang and Stall, either alone or in combination, do not teach heating the lithium niobate structure in a sealed oxygen gas atmosphere substantially lacking in H_2O , as claimed. Since the prior art references fail to teach or suggest all the claim limitations, they do not render the claimed invention obvious. None of other cited references (Chen and Byer) suggests avoiding H_2O from the process, either.

Regarding the pressure, Chang does not teach the step of pressurizing the oxygen gas in the sealed chamber to exceed ambient atmospheric pressure, as the Examiner has correctly acknowledged. However, the Examiner alleges that it would have been obvious to modify Chang’s method as per Stoll to pressurizing the oxygen gas to exceed ambient atmospheric pressure because Stoll states “larger crystals will necessarily require proportionately greater pressure of oxygen.” However, the Examiner’s allegations are not correct for the following reasons.

The statement of Stoll (column 4, lines 33-35) reads, "The oxygen is applied at a pressure preferably between 10-100 atmospheres. *In this regard*, larger crystals will necessarily require *proportionately* greater pressure of oxygen (emphasis added)." Therefore, the statement is made in the context of the already pressurized oxygen, and thus Stoll only suggests adjusting the *high* pressure in accordance with the size of the crystal within that pressure range. Stoll does not suggest modifying a system working at an ambient atmospheric pressure (Chang) to a pressurized system.

Accordingly, the claimed invention would not have been obvious from Chang, Stoll, or the alleged combination thereof. It is respectfully requested that the rejection of claims based on Chang and Stoll be withdrawn.

Claims 57 and 61

Claim 57, as amended, defines a method for annealing a lithium niobate structure, including heating the lithium niobate structure in a sealed oxygen gas (O₂) atmosphere substantially lacking in H₂O to within a temperature range from about 150 degrees Celsius and less than 400 degrees Celsius, and pressurizing the sealed oxygen gas atmosphere to exceed ambient atmospheric pressure. Claim 61 includes the same distinctive features for a lithium tantalate structure.

Since claims 57 and 61 includes the same features of heating the lithium niobate/tantalate structure in a sealed oxygen gas atmosphere substantially lacking in

H₂O as that of claims 1 and 22, the above arguments are equally applicable here. Thus, claims 57 and 61 are patentable at least for the same reason.

In addition, with respect to the temperature range, Chang only teaches the annealing temperature range of 400-1000°C, and Stoll teaches that between 800°C and 1100°C. Thus, Chang and Stoll, alone or combined, do not teach the claimed temperature range. There is no suggestion, motivation, or desirability for using the anneal temperature lower than 400°C in either reference, either.

Accordingly, the claimed invention would not have been obvious from Chang, Stoll, or the alleged combination thereof. It is respectfully requested that the rejection of claims based on Chang and Stoll be withdrawn.

Claims 9 and 35

Claim 9 defines an annealing method including locating a lithium niobate powder in a space proximate to the lithium niobate structure to retard outgassing of lithium oxide (Li₂O) from the lithium niobate structure, and separating the space including the lithium niobate powder from the lithium niobate structure with an interface porous to lithium oxide gas outgassed from the lithium niobate powder. The interface is substantially without porosity to the lithium niobate powder. Claim 9 further includes heating the lithium niobate structure in a sealed oxygen gas and pressurizing the oxygen gas above ambient atmospheric pressure. Claim 35 includes the similar distinguishing features for a lithium tantalate structure.

With respect to the sealed and pressurized oxygen, Chang and Stoll do not provide necessary motivation or desirability to modify Chang with the teaching of Stoll, as discussed above.

Regarding the interface, the examiner correctly acknowledges that neither Chang nor Stall discloses the step of separating the space including the lithium niobate powder from the lithium niobate structure with an interface porous to lithium oxide gas outgassed from the lithium niobate powder. However, the Examiner alleges that it would have been obvious to modify the alleged Chang-Stoll combination by Chen's teaching, because Chen's wrapping the lithium niobate sample in platinum foil during annealing in the LiNbO_3 powder in order to avoid physical contact with the LiNbO_3 powder substantially reduces the desired change in the refractive index.

However, the Examiner has misunderstood the Chen's teaching. According to Chen's description, it is desirable to achieve Li_2O in-diffusion while suppressing the Li_2O out-diffusion by the LiNbO_3 treatment during the anneal process. In Chen, the achievement of the Li_2O in-diffusion with the LiNbO_3 treatment in the annealing process is measured by change in the refractive index, and the index approaches to a certain value as the in-diffusion process completes (column 5, lines 34-38). Chen suggests that fast reaction rate (80% of the in-diffusion process occurs within 30 minutes and the asymptotic value was approached after 2.5 hours) in its experiment indicates that the LiNbO_3 powder treatment is effected both by the diffusion process and by solid-solid

interaction (i.e., physical contact) with the powder (column 5, lines 35-41). Then, Chen wrapped the sample with platinum foil in order to see the reaction rate of the Li_2O in-diffusion process without such physical contact. Without such direct solid-solid interaction, the change in the refractive index, which is the measure of the Li_2O in-diffusion achievement, was substantially reduced, indicating a very low reaction rate (column 5, lines 41-46). That is, Chen shows that foil-wrapping the substrate greatly slows the process. Such a slowed process is an undesirable result and thus one of ordinary skill in the art would not wrap the substrate with foil in accordance with Chen's teaching.

Therefore, Chen discourages such foil-wrapping and rather suggests providing the lithium niobate sample with direct physical contact with the LiNbO_3 powder to enhance the Li_2O in-diffusion. In fact, none of Chen's examples wraps the lithium niobate sample with foil, but the sample is always placed directly in LiNbO_3 powder (or molten LiNbO_3). Accordingly, the Chen's suggestion teaches away from wrapping the lithium niobate in foil or from providing any interface between the lithium niobate and the LiNbO_3 powder. One of ordinary skill in the art would place LiNbO_3 powder in direct contact with the lithium niobate sample with Chen's teaching.

Accordingly, the claimed invention would not have been obvious from teachings of Chang, Stoll, Chen, or any combination thereof. It is respectfully requested that the rejection of claims based on Chang, Stoll and Chen be withdrawn.

Dependent Claims

Claims 2-8, 44, and 49-50 depend directly or indirectly from claim 1, and claims 27-34 and 51-52 depend directly or indirectly from claim 22, and thus include the limitations of respective independent claims. Claims 11-13, 45-48, and 55-56 depend directly or indirectly from claim 9, and claims 37-43 and claims 53-54 depend directly or indirectly from claim 35, and thus include the limitations of respective independent claims. Claims 59-60 and claims 63-63 depend from claims 57 and 61, respectively, and thus include the limitations of respective independent claims. Thus, the arguments set forth above regarding the respective independent claims are equally applicable here. The base claims being allowable, the dependent claims must also be allowable.

Furthermore, with respect to a specific pressure range of the claimed invention, the Examiner also alleges that it would have been "obvious to adjust the pressure/process variable through routine experimentation to obtain the best result." As recited in claims 5, 32, 41, and 47, the claimed invention specifically recites the oxygen pressure range of about 2 psi - 25 psi (i.e., about 0.141 kg/cm² to 1.76 kg/cm²) above ambient atmospheric pressure. Since the pressure range (10-100 atmospheres) of Stroll is much higher than that of the claimed invention, even though Stoll's teaching might be combined with Chang, the combination would still fail to teach or suggest all the claim limitations.

In addition, the claimed pressure range would not be obvious from Chang, Stoll, or the combination thereof for the following reasons. Chang does not mention any

pressurizing of the annealing gas, as discussed above. Stoll discloses iron-doped lithium niobate crystals for holographic applications (column 1, lines 26-29, and 56), and teaches annealing of the crystal by pressurizing a pure oxygen gas as high as 10-100 atmospheres and then heating at around 950°C. Stoll's purpose is to achieve a desired trivalent ion (Fe^{3+}) to divalent ion (Fe^{2+}) ratios without adversely affecting the ability of the lithium niobate crystals to function in holographic applications (column 3, line 65 to column 4, line 1), and there is no mention to any optical waveguides or modulators in Stoll. Thus, the alleged "best result" is limited to that for holographic applications described in Stoll. The claimed pressure range is to avoid the green discoloration as described in the present specification on page 12, line 14 to page 13, line 2. Since Stoll adjusts the oxygen pressure only by the crystal size and mentions nothing about effects of the annealing pressure on discoloring, the claimed pressure range would not be obtained by routine examination with Stoll's teaching.

In view of the foregoing, it is respectfully asserted that the claims are now in condition for allowance.

Request for Allowance

It is believed that this Amendment places the above-identified patent application into condition for allowance. Early favorable consideration of this Amendment is earnestly solicited.

If, in the opinion of the Examiner, an interview would expedite the prosecution of this application, the Examiner is invited to call the undersigned attorney at the number indicated below.

Respectfully submitted,
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Dated: January 27, 2003

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Marked-Up Version of Claims Showing Changes Made

1. (Twice Amended) A method for annealing a lithium niobate (LiNbO_3) structure, the method comprising:

heating the lithium niobate structure in a sealed [pure] oxygen gas (O_2) atmosphere substantially lacking in H_2O ;
pressurizing the sealed [pure] oxygen gas atmosphere to exceed ambient atmospheric pressure;
maintaining temperature and pressure for an anneal period; and
cooling to room temperature.

12. (Thrice Amended) The method of claim 9 wherein the sealed [pure] oxygen gas atmosphere substantially lacks in H_2O .

22. (Thrice Amended) A method for annealing a lithium tantalate (LiTaO_3) structure, the method comprising:

heating a lithium tantalate structure in a sealed [pure] oxygen gas (O_2) atmosphere substantially lacking in H_2O ;
pressurizing the sealed [pure] oxygen gas atmosphere to exceed ambient atmospheric pressure;
maintaining temperature and pressure for an anneal period; and
cooling to room temperature.

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38. (Once Amended) The method of claim 35 wherein the sealed [with a sealed pure] oxygen gas atmosphere substantially lacks [lacking] in H₂O.

57. (Once Amended) A method for annealing a lithium niobate (LiNbO₃) structure, the method comprising:

heating the lithium niobate structure in a sealed oxygen gas (O₂) atmosphere substantially lacking in H₂O to within a temperature range from [of] about 150 degrees Celsius and less than 400 [to about 500] degrees Celsius;

pressurizing the sealed oxygen gas atmosphere to exceed ambient atmospheric pressure;

maintaining temperature and pressure for an anneal period; and

cooling to room temperature.

59. (Once Amended) The method of claim 57 wherein said heating is within a temperature range from [of] about 300 degrees Celsius and less than [to about] 400 degrees Celsius.

61. (Once Amended) A method for annealing a lithium tantalate (LiTaO₃) structure, the method comprising:

heating a lithium tantalate structure in a sealed oxygen gas (O₂) atmosphere substantially lacking in H₂O to a temperature range from [of] about 150 degrees Celsius and less than 400 [to about 500] degrees Celsius;

pressurizing the sealed oxygen gas atmosphere to exceed ambient atmospheric pressure;

maintaining temperature and pressure for an anneal period; and
cooling to room temperature.

63. (Once Amended) The method of claim 61 wherein said heating is within a temperature range from [of] about 300 degrees Celsius and less than [to about] 400 degrees Celsius.

65. (New) The method of claim 1 wherein the sealed oxygen gas atmosphere is a pure oxygen gas atmosphere.

66. (New) The method of claim 9 wherein the sealed oxygen gas atmosphere is a pure oxygen gas atmosphere.

67. (New) The method of claim 22 wherein the sealed oxygen gas atmosphere is a pure oxygen gas atmosphere.

68. (New) The method of claim 35 wherein the sealed oxygen gas atmosphere is a pure oxygen gas atmosphere.

69. (New) The method of claim 57 wherein the sealed oxygen gas atmosphere is a pure oxygen gas atmosphere.

70. (New) The method of claim 61 wherein the sealed oxygen gas atmosphere is a pure oxygen gas atmosphere.